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LOW-COST WINTER FEEDING SYSTEMS FOR COW-CALF PRODUCERS

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EXECUTIVE SUMMARY

This project is focused on comparing beef cow performance and reproductive efficiency, soil and crop factors and economic differences between four different winter management systems. Study results will complement information already available for western Canada and provide new information for winter feeding beef cattle in the Black soil zone of Saskatchewan.

With feed costs rising, reducing the cost of production is crucial in today's operations in order to maintain sustainable production and the viability of cow/calf operations. In order to be both economically and environmentally sustainable, producers must take advantage of low cost feed sources and systems, while at the same time ensuring a high plane of production management. During the past number of years producers have moved towards extensive winter feeding systems in attempts to reduce costs associated with winter feeding. While this is economically beneficial for producers, questions have been raised regarding the impact of these systems on cow performance, soil health, and subsequent crop production.

This study was conducted to evaluate the effects of winter feeding systems such as drylot feeding, bale grazing, swath grazing and straw-chaff grazing on cow performance, cow reproduction, soil nutrients, soil compaction, crop yield and cost of production between systems. In the first year, cows on swath grazing had a 4% lower final body weight compared to drylot fed cows. Under winter field conditions, feed allocation is important because cows in extended grazing require extra energy to offset the energy cost of walking, foraging and maintenance during winter. However, winter feeding system had no effect on subsequent year's calf birth weight or calving pattern. Estimated dry matter intake for cows on all feeding systems was slightly lower or similar to NRC (1996) requirements. Final body weights of cows on all feeding systems were similar during the last two years of the study.

Soil nitrate nitrogen levels between feeding systems were related to landscape position (slope) with levels 2X greater at low than at high slopes on bale graze sites. Nitrogen distribution was affected by the swath graze pattern and was associated with feeding site. Greater distribution of feed in this system resulted in increased nutrient distribution. Applying compost and manure mechanically on the field resulted in lower nitrate nitrogen levels compared to areas which received no manure as the site had a history of previous manure application. Phosphorous distribution patterns were seen to correlate with feeding site and parallels could be drawn between manure distribution and crop biomass the following year. Soil compaction was not a problem on any winter field feeding system.

Finally over the 3-year study period, winter feeding systems such as straw-chaff grazing, bale grazing and swath grazing were 5, 6 and 40% lower respectively, in cost per cow per day compared to winter feeding the same cows in drylot pens.

INTRODUCTION

Producers use several management systems for wintering beef cows, with each system having a different impact upon the plant-animal-soil interface, as well as the sustainability of the operation. Least-cost production systems are essential when dealing with the economics associated with animal agriculture; however, agriculture has been criticized concerning negative impacts on the environment. The need for environmentally sensitive, low cost feeding systems is crucial. However research information regarding winter feeding systems for beef cattle is limited. Through proper management of nutrients, producers can maintain a positive whole farm nutrient budget; thus increasing their economic gains and decreasing the environmental concerns pertaining to agriculture (Van Horn et al. 1996). Manure is a valuable resource and must be managed to ensure proper utilization of its nutrients. Implementing techniques such as proper manure handling and application, sustainable wintering sites, and composting can benefit producers economically as well as decrease the environmental impact from the operation.

Historically, many producers winter their beef herd using what is termed a traditional drylot system. The winter feeding period for beef cattle (*Bos taurus)* in Western Canada is typically 200 d per year (Mathison, 1993). Therefore a large cost is associated with supplying nutrients to pregnant beef cows. Studies have shown that harvested forage, such as hay, costs between $.03 and $.07 per pound of dry matter which is double the cost for the same amount of nutrients from pasture (Kallenbach 2000). The cost of feeding bales has been reported by Volesky et al. (2002) to be 3% of the cost of harvesting the hay. This then leads to a substantial increase in cost of production per pound of beef for the producer. The producer will also have extra expenses related to corral cleaning, manure handling and facilities maintenance. Studies have shown that fall grazing annuals can result in improved cow body condition and postpone the onset of weight loss, as well as decrease costs by $47 per head (Willms et al. 1993). Alberta Agriculture, Food, and Rural Development (1998) reported that cows grazing windrowed oats maintained body condition and backfat similar to cattle fed a traditional winter ration. A recent study at the Western Beef Development Centre's, Termuende Research Ranch at Lanigan, Saskatchewan, compared field wintering systems on pasture land, to traditional drylot wintering systems. The study reported that wintering systems had no effect on cow weight or condition and reduced costs by up to $0.58 per cow per day (Jungnitsch et al. 2005). Lardner (2005) has shown that wintering systems can have a positive effect on nutrient cycling of a pasture stand; however research evaluating winter feeding on annual cropped land is limited. Finally, the objectives of this study are to:

1. Evaluate the effect of winter feeding systems on cow performance, apparent intake and reproductive efficiency
2. Evaluate the efficiency of **intensive** and **extensive** cow-wintering systems for managing nutrients from beef cattle manure
3. Evaluate subsequent crop response post-winter feeding
4. Evaluate the economic differences (total cash and overhead costs) between wintering systems

GENERAL MATERIALS AND METHODS

Study Site

The feeding trial was conducted at the Western Beef Development Center's (WBDC) Termuende Research Ranch located near Lanigan, Saskatchewan, Canada. This area is located in the east central area of the province on the Saskatchewan Plain and consists primarily of Chernozemic Black Oxbow soils.

Winter Feeding Systems

The feeding systems included swath grazing (SG), bale grazing (BG), and straw/chaff grazing (ST/CH) compared to a traditional drylot (DL) pen feeding system. In June of each year 40 hectare (ha) of forage barley (cv. Ranger) was seeded at 0.8 bushels per ha, along with 56 kg ha^{-1} actual nitrogen (N). The field was then sub-divided into ten, 4-ha paddocks using electric fence. The barley crop was swathed at mid dough stage for either greenfeed or swath grazing. Straw/chaff paddocks were left to mature and the grain was combined each year in late September. A whole-buncher (AJ Manufacturing, Calgary AB) was attached to the combine to collect the piles of straw/chaff residue for winter grazing.

Experimental Animals

The cows used in the study were obtained from the main herd of the WBDC. In the first year (2005-06) 180 commercial cows were on trial with an average weight of 630.51 ± 3.9 kg, average BCS of 2.77 ± 0.06 (five point system), average age of 6.9 ± 1.08 (years), average gestation of 110 ± 17.69 (days), and average rib fat of 6.00 ± 0.28 (mm). In year two (2006-07), 180 commercial cows (primarily same cows) were on trial with an average weight of 645.50 ± 4.4 kg, average BCS of 2.61 ± 0.08 (five point system), average gestation of 93 ± 4.9 (days), and average rib fat of 3.85 ± 0.56 (mm). In the final year (2007-08), 120 cows (primarily same cows) were on trial with an average weight of 711.67 ± 4.2 kg, average BCS of 2.73 ± 0.08 (five point system), average gestation of 105 ± 9.8 (days), and average rib fat of 6.73 ± 0.45 (mm).

Each year the cows were pregnancy checked by a veterinarian prior to the start of trial (SOT) to eliminate open cows. The trial consisted of four winter feeding treatments with 3 replicates (n=3) of each treatment and each replicate group containing 15 animals. Each replicate group of cows (n=15) was confined in the 4 ha paddock and managed using electric fence to control access to feed. Drylot cows were housed in replicated pens at the Termuende Research Ranch facilities. Each year 180 crossbred cows were stratified by body weight, body condition, rib fat, age and stage of gestation and assigned randomly to one of four treatments. All cattle were cared for in accordance with the principles and guidelines set out by the Canadian Council on Animal Care (1993).

The 2005-06 trial lasted 78 days from 16 November 2005 to 2 February 2006, while the 2006-07 trial lasted 21 days from 30 November 2006 to 22 December 2006 due to inclement weather which led to inaccessibility of the feed. Finally the 2007-08 trial lasted 38 days from 11 December 2007 to 17 January 2008.

Forage quality

In 2005-06, feed for the BG and DL animals consisted of barley greenfeed, which averaged 81.04 % dry matter (DM), 61.42% total digestible nutrients (TDN), and 12.70% crude protein (CP) (Table 1). Swath graze feed consisted of barley swaths averaging 62.38 % DM, 61.26% TDN, and 13.79% CP. Straw/chaff feed consisted of straw/chaff plus a supplement range pellet. Straw/chaff contained on average of 56.66% DM, 49.76% TDN, and 10.22 % CP. The range pellet consisted of 88.4 %DM, 75.01%TDN, and 19.6% CP (Table 2).

Table 1. Chemical composition of forage fed to wintering cows

Item[z]	DM (%)	CP (%)	TDN (%)	DE (Mcal/kg)	Ca (%)	P (%)	K (%)	Mg (%)	Na (%)
2005/2006									
Swath Graze	62.38	13.79	61.26	2.69	0.52	0.32	3.23	0.27	0.19
Straw/Chaff	56.66	10.22	49.76	2.19	0.48	0.25	2.26	0.22	0.28
Bale Graze	83.04	12.70	61.42	2.67	0.43	0.34	2.25	0.25	0.17
Drylot	83.04	12.70	61.42	2.67	0.43	0.34	2.25	0.25	0.17
2006/2007									
Swath Graze	95.72	14.12	66.64	2.93	0.37	0.31	2.19	0.26	0.18
Straw/Chaff	95.59	9.33	45.52	2.00	0.43	0.14	2.64	0.30	0.42
Bale Graze	81.14	13.97	70.79	3.11	0.42	0.27	2.75	0.30	0.22
Drylot	81.14	13.97	70.79	3.11	0.42	0.27	2.75	0.30	0.22
2007/2008[y]									
Swath Graze	69.25	12.80	70.02	3.07	0.24	0.35	1.36	0.22	0.17
Straw/Chaff	69.40	10.45	48.41	2.12	0.40	0.23	1.85	0.17	0.18
Bale Graze	84.65	12.50	68.49	3.00	0.68	0.32	1.80	0.41	0.11
Drylot	84.65	12.50	68.49	3.00	0.68	0.32	1.80	0.41	0.11

[z]DM=dry matter; CP=crude protein; TDN=total digestible nutrients (calculated using Penn State equation); DE=digestible energy; Ca=calcium; P=phosphorous; K=potassium; Mg=magnesium; Na=sodium

[y]2005-2006 & 2006-2007 = Analyzed by Norwest Labs; 2007/2008 = Analyzed by ALS Laboratory Group

Table 2. Nutrient composition of supplement fed to cows (dry matter basis)

Item[z]	2005-06	2006-07	2007-08
Dry matter (%)	88.4	87.7	87.9
TDN (%)	75.1	78.7	77.8
Crude protein (%)	19.6	16.2	18.2
Calcium (%)	0.86	1.02	1.77
Phosphorous (%)	0.51	0.67	0.78
Magnesium (%)	0.26	0.31	0.34
Potassium (%)	0.89	0.83	0.82
Sodium (%)	0.36	0.17	0.33

[z]TDN=total digestible nutrients;

Rations in 2006-07 for the BG and DL cows again consisted of barley greenfeed, which contained on average 81.14 % DM, 70.79% TDN, and 13.97% crude protein. Swath graze rations consisted of barley swaths and contained on average, 95.72 % DM, 66.64%TDN, and 14.12% crude protein. Straw/chaff rations consisted of straw/chaff as well as a supplement range pellet. The straw/chaff consisted of 95.59% DM, 45.52% TDN, and 9.33 % CP. Range pellet composition was 87.8% DM, 78.97 % TDN, and 16.2% crude protein. Rations in 2007-08 for the BG and DL cows again consisted of barley greenfeed, which contained on average 84.65 % DM, 68.49% TDN, and 12.5% CP. Swath graze rations consisted of barley swaths and contained on average, 69.25 % DM, 70.02%TDN, and 12.8% CP. Straw/chaff rations consisted of straw/chaff as well as a supplement range pellet. The straw/chaff consisted of 69.4% DM, 48.41% TDN, and 10.45% CP. Range pellet composition was 87.9% DM, 77.8 % TDN, and 18.2% crude protein. Yearly variation in feed quality is most evident in the straw/chaff & swath graze treatments which had large increases in DM% from 2005-06 to 2006-07. This fluctuation in moisture reflects the variance in forage quality and nutrient intake from these two forage types, which must be taken into account when using this type of forage in field feeding.

Feeding system layout and design

Drylot (DL) animals were housed in 3 outdoor pens surrounded by wooden slated fences. Each pen contained an open faced cattle shelter and one round bale feeder. Wood chips were used for bedding for comfort of the animal, based on the judgment of the herdsperson.

Cattle in the field feeding systems were managed in a 40 ha field, further divided into 10 - 4 ha replicates (n=3) paddocks (15 cows per paddock). The outer perimeter of each paddock was fenced with high tensile electric wire and feed was allocated on a 3-day feeding period using low tensile electric fence. Water was supplied in troughs and portable wind breaks with dimensions (10 X 6 m) were supplied in each paddock.

Estimating available crop yield

Prior to start of feeding trial each year, available forage yield was estimated using two different techniques. The first technique, was a direct method using 0.25 m^2 quadrat samples (n=15) determined within each replicate paddock in the fall prior to swathing the crop for greenfeed or swath grazing. The second direct technique involved taking estimates of available feed weight in each field system by randomly weighing (a) 10, (30 x 3 m) sections of swath in each SG replicate paddock where feed was placed on a tarp, weighed and placed back in swath, (b) 40 straw/chaff piles in each ST/CH paddock where piles were placed on a tarp, weighed and placed back in pile; and (c) 12 bales in each BG and DL replicate were weighed using a truck scale. Forage yield estimation techniques were followed as described by Volesky et al. (2002) and Baron et al. (2004).

Laboratory analysis of forage samples

Available forage was sampled from each feeding system prior to start of test (SOT) and every 60 days throughout the trial to determine changes in feed quality. All forage samples were placed in a forced air oven at 55°C for 72 h to obtain DM content. Samples were then ground to pass through a 1 mm screen using a Christie-Norris mill (AOAC 1990). All samples were then submitted for laboratory analysis.

In 2005-06 and 2006-07, forage samples were analyzed using Norwest Labs, Lethbridge AB. Analyses included moisture (AOAC, method 935.29), neutral detergent fibre (NDF) (FAP, method 5.1) and acid detergent fibre (ADF) (AOAC, method 973.18). Crude protein (CP) was determined by the Leco method (AOAC method 990.03), and minerals by AOAC, method 985.01.

In 2005-06, forage samples were also analyzed in duplicate at the Department of Animal and Poultry Science laboratory. Analysis included moisture (AOAC, method 930.15), ether extract (EE) (AOAC, method 920.39), ADF (AOAC, method 973.18) and acid detergent lignin (ADL) (AOAC, method 973.18) (AOAC 1990). Neutral detergent fibre (NDF) was analysed according to the procedure of Van Soest et al. (1991). Heat stable α- amylase (A3306, Sigma Chemical Co., St. Louis, MO) was included in the NDF procedure at 0.17 ml per 0.5 g sample. Crude protein (CP) was determined by the Kjeldahl nitrogen method (AOAC method 976.05) using a Kjeltec 1030 auto analyser. The Kjeltec 103 auto analyserwas also used to determine acid (ADFIP) and neutral detergent fibre insoluble protein (NDFIP) (AOAC, method 984.18) with residues recovered on Whatman No. 54 paper.

Dietary energy predictions

Two methods were used to determine dietary energy (DE) during the feeding period (Table 3). The first method used the Pennsylvania State equation which predicts percent total digestible nutrients (TDN) based on acid detergent fiber (ADF) levels (Adams 1995).

$$4.898+\{89.796*[1.0876-(0.0127*ADF)]\}$$

where ADF is expressed on a DM basis.

The second method calculated %TDN according to Weiss et al. (1992).

{0.98*(1000-{(NDF*10)-(CP*NDFIP/10)+[0.7*(CP*ADFIP/10)]}-(CP*10)-(ash*10)+[0.7*(CP*ADFIP/10)]-(EE*10))+[-0.0012*(CP*ADFIP/10)]^2*(CP*10)+2.25* [(EE*10)-10]+0.75*({(ADL*10)-(CP*NDFIP/10)+[0.7*(CP*ADFIP/10)]}-(ADL*NDF/10))*[1-((ADL*NDF/10)/{(NDF*10)-(CP*NDFIP/10) +[0.7* (CP*ADFIP/10)]})^(0.667)]-70}/10

where neutral detergent fiber (NDF), acid detergent fiber (ADF), crude protein (CP), ether extract (EE), and ash are expressed as % dry matter (DM); neutral detergent fiber insoluble protein (NDFIP) and acid detergent fiber insoluble protein (ADFIP) were expressed as % CP; acid detergent lignin (ADL)was expressed as %NDF.

Table 3. Energy values of forages (TDN)

Item[2]	Swath graze	Straw-chaff	Bale graze	Drylot
Weiss equation (%)	58.86	54.30	60.36	62.16
Penn State equation (%)	61.15	50.42	69.49	61.00

[2]TDN=total digestible nutrients;

Differences in TDN calculated using the two equations sets (Table 3) were suggested to be a factor in forage quality and amount of feed allocated in 2005-06 which may have affected animal performance.

These factors were considered in deciding which energy values were more accurate when evaluating feed quality in this trial. When comparing the Pennsylvania State equation to Weiss et al. (1992) it is clear that the latter method uses a more comprehensive approach based on nutrient content to determine ration energy values.

Feeding

The cows were allocated feed in each system based on rations formulated using CowBytes® software. Rations were formulated to meet nutrient requirements including support for gravid uterine growth in accordance with requirements as presented by the National Research Council (NRC 1996). The amounts allocated were intended for maintenance of body condition, with no weight gain above that of conceptus growth. Cows never grazed the entire paddock area in a winter grazing period; paddock areas grazed ranged from 0.11 to 0.15 ha over the three years. Feed was allocated *ad libitum* every three days, with an estimated 5-10% carryover. Feeding periods were 78, 21 and 38 days in 2005-06, 2006-07 and 2007-08, respectively.

Soil nutrients, soil density and crop yield

Several parameters were measured to determine the effect of winter feeding systems on the soil profile including soil nutrients, nutrient distribution, soil density, and crop yield. In year one (2005-06), a small plot manure application trial was conducted on the same feeding site to determine the effect of raw versus composted manure application on soil nutrients, distribution, density and crop yield.

Soil nutrient availability was also measured in each winter feeding paddock to determine the effects of extensive winter feeding system on plant available soil nitrogen, phosphorous, and potassium. Square meter (1.0 m^2) quadrats were taken in each winter feed treatment and each manure application trial (n=5), in order to determine total crop biomass.

Statistical analysis

Statistical analysis was conducted using a one way ANOVA of the Proc Mixed Model procedure of SAS (SAS Institute Inc., Cary, NC).

Cow data (average daily gain (ADG), rib and rump fat) was analyzed using a completely randomized design (CRD). Treatments were winter feed systems which included swath grazing, bale grazing, straw/chaff grazing and drylot feeding. Each cow in the trial was considered a sampling unit for a total of 180 sampling units. Each replicate group of cows (n=3) was considered an experimental unit for a total of 36 experimental units over the three year study. Tukeys multiple range test was applied to determine whether the treatment means were different. Differences were considered significant when $P<0.05$ and all differences were noted when $P<0.10$ (trends). Reproductive data was analyzed using CHI square analysis (SAS Institute Inc., Cary, NC).

Soil data (soil nutrients) from the manure application trial was analyzed using a randomized complete block design (RCBD) with 4 replicates per treatment. Treatments included a check (no manure applied), 1X rate of manure (22.4 tons/ha) and 1X equivalent rate of compost (6.72 tons/ha). Analysis was done to determine the effect of treatment on soil nutrient profile. Each replicate was considered an experimental unit for a total of 12 experimental units over the one year period.

Soil data (soil nutrients) from the winter feeding trial was analyzed using a randomized complete block design (RCBD). Treatments included swath graze, bale graze, and straw/chaff. Analysis was done to determine the effect of treatment on soil nutrient profile and soil compaction. Each replicate will be considered an experimental unit for a total of 12 experimental units over a one year period. LSD multiple range test will be applied to determine whether the treatment means are different. Differences will be considered significant when $P< 0.10$.

Environmental data

Daily minimum and maximum temperatures were obtained from Agriculture and Agri-Food Canada, as well as daily precipitation obtained from Environment Canada. These were then averaged in order to obtain average monthly temperatures, and precipitation. Daily temperatures were averaged for the duration of each trimester of pregnancy to determine current temperature for input into the NRC model, as

suggested by Fox and Tylutki (1998). To determine the previous month's average temperature, daily temperatures were averaged from four weeks prior to the beginning of each trimester to four weeks prior to the end of each trimester.

EFFECT OF WINTER FEEDING SYSTEM ON ANIMAL PERFORMANCE & REPRODUCTIVE EFFICIENCY

Several techniques were used to determine the effects of winter feed system on cow performance, including measuring body weight change, body condition scoring and ultra-sounding. Reproductive efficiency of cows was also determined during the 3-year study. Measurements of body weight change and body condition were taken at the start and end of test each year. Data from cows in the field feeding systems was collected using a portable handling and chute facility and data from the intensive system was collected at the Termuende Research Ranch facilities.

Materials & Methods

Weight change

Live bodyweight was used as an indicator of cow performance and treatment effect. Each cow was weighed twice at the start of test (SOT) and twice at the end of test (EOT) over two consecutive days. In 2005-06, weights were also taken every 21 days throughout the trial. Length of trial in 2006-07 and 2007-08 did not allow for 21 day weights. Weights were taken in the morning prior to feeding and watering to account for gut fill variability.

Body fat reserves

Ultra sound measurements were used as an indicator of cow performance as well as treatment effect. Rib fat measurements were taken by an independent technician at the SOT and at the end of test EOT. An Echo Camera SSD-500 diagnostic real time ultra-sound (RTUS) unit (Overseas Monitor Corporation Ltd., Richmond BC) equipped with a UST 5044 - 17 cm 3.5 MHz linear array transducer was used. One location to estimate body fat reserves was used, which included between 12th and 13th rib.

Body condition

Body condition was used to estimate cow performance throughout the trial. An independent technician scored the cows using the short ribs as a measurement site, and a scale of 1 to 5 (1 = emaciated to 5= grossly fat) (Lowman et al. 1976). Body condition was measured at the start of test (SOT) and at the end of test (EOT).

Reproductive efficiency

Animals were pregnancy checked prior to start of test to ensure all animals on trial were pregnant. Reproductive data collected following winter feeding included calf

birth date, calf birth weight and calving pattern. This data was used to determine treatment effects on calf birth weight and calving pattern.

Estimated apparent animal intake and feed utilization

Estimated apparent dry matter intake (DMI) was determined during the trial in all feeding systems. Residual feed was estimated each spring by randomly weighing remaining residue on swath grazed areas, straw-chaff piles and bales after each winter feeding period. Manure and any foreign debris not associated with the crop and grazing were removed. Samples weighed included (a) 10, 30 x 3 m sections of swath in each swath graze (SG) replicate, (b) 30 piles per straw-chaff (ST/CH) replicate and, (c) 12 bales sites in each bale graze (BG) replicate and 1 bale site per drylot (DL) replicate. Residual feed was then subtracted from the amount of allocated feed to estimate animal intake and utilization. Feed utilization was compared between treatments to determine feed wastage. All estimates were determined on a dry matter basis.

Results and Discussion

In 2005-06, cows were able to swath graze, straw-chaff graze and bale graze from 2005 November 16 to 2006 February 2 (78 d), with snow arriving the first week of December. In 2006-07, cows grazed from 2006 November 29 to 2006 December 21 (21 d) with snow on the ground throughout the trial and as deep as 14 cm. In the second year (2006-07), winter field feeding systems were severely restricted due to freezing rain and snow via several storms over a 45 day period. Managing the cows in these systems was very difficult due to inaccessibility to the feed, frozen feed and drifting snow. Snow arrived in early December in the last year (2007-08) and cows were able to graze from 2007 December 11 to 2008 January 17 (38 d).

Initial body weights during all years of the study did not differ significantly between winter feeding systems ($P>0.05$) (Table 4). During the first year of the study (2005-06), changes in body weight (BWC) were observed across treatments with differences between the SG and DL treatments ($P<0.05$) (Table 4). This difference was also evident in the final bodyweights (BW) of cows on SG and DL cows. During the second year of the study (2006-07), there were no differences in initial or final weight (kg) between treatments; however there was a difference ($P<0.05$) in BWC between the DL and ST/CH treatments, 32.91 and 6.54 kg, respectively. In the feeding period of 2007-08 no differences were observed between cow weights. Additionally, no differences ($P>0.05$) were observed between winter feeding systems for estimated dry matter intake (Table 5).

Table 4. Effects of winter feed system on cow growth performance over three years.

	Body weight[z] (kg)			Body Condition Score[y] (1-5)			Rib Fat (mm)		
	Initial	Final	Change	Initial	Final	Change	Initial	Final	Change
2005-2006									
Drylot	629.2	652.6*a*	23.4*a*	2.75	2.74*a*	-0.01*b*	6.09	6.98*a*	0.89*b*
Bale graze	632.0	642.4*ab*	10.3*ab*	2.79	2.76*a*	-0.03*b*	5.78	5.62*b*	-0.16*c*
Straw/chaff	631.1	640.4*ab*	9.4*ab*	2.79	2.49*b*	-0.30*a*	6.03	4.57*bc*	-1.46*a*
Swath graze	629.7	621.7*b*	-7.9*b*	2.74	2.68*ab*	-0.06*b*	6.09	4.91*b*	-1.18*ab*
SEM[x]	2.52	4.76	4.21	0.04	0.04	0.06	0.17	0.24	0.20
2006-2007									
Drylot	597.4	630.3	32.9*a*	2.65	2.70*ab*	0.05	4.33	4.76*a*	0.42
Bale graze	598.0	612.7	14.7*ab*	2.56	2.65*ab*	0.09	3.64	4.09*ab*	0.44
Straw/chaff	601.0	607.5	6.5*b*	2.59	2.53*b*	-0.05	3.31	2.91*b*	-0.40
Swath graze	598.2	626.3	28.1*a*	2.64	2.72*a*	0.08	4.11	4.27*a*	0.15
SEM	5.13	8.47	5.18	0.05	0.04	0.03	0.25	0.28	0.23
2007-2008									
Drylot	643.2	650.3	7.1	2.65	2.70*ab*	0.05	4.33	4.75*a*	0.42
Bale graze	643.8	652.2	8.3	2.56	2.65*ab*	0.09	3.64	4.09*ab*	0.44
Straw/chaff	647.4	652.4	5.1	2.59	2.53*b*	-0.05	3.31	2.91*b*	-0.40
Swath graze	647.6	660.1	12.5	2.64	2.72*a*	0.08	4.11	4.27*a*	0.15
SEM[x]	2.65	11.87	10.19	0.05	0.04	0.03	0.25	0.28	0.23

a-d Values in columns followed by different letters differ ($P < 0.05$)

[z]body weights have been adjusted for conceptus growth

[y]body condition score was based on the Scottish system (Lowman et al. 1976) and was scored from 1 (emaciated) to 5 (grossly fat).

[x]SEM=standard error of the mean

The observed differences in BWC in 2005-06 between the intensive (DL) and extensive (SG) system suggests an adaptation (-15 °C mean temp [Nov 15 to Dec 15]; Environment Canada 2005) and environmental effect on cow performance in the field grazing system. However, cows were allocated feed based on similar energy levels as determined by lab results from Norwest Labs (Table 3). When energy was calculated by the Weiss (1992) formula for swath grazed feed, values were determined to be 7 to 8 % lower, thus more feed should have been allocated. These results indicate that cows grazing swath, straw-chaff piles or bales require at least 18 to 21% extra energy as suggested by McCartney et al. (2004), possibly to offset the energy costs of walking, foraging and maintaining body temperature during winter. In addition, NRC (1996) states that maintenance energy requirements increase by 10 to 20% for field grazing as compared to penned cattle. In this study, cows in field were more exposed to wind during winter grazing as compared to DL cows that were in sheltered pens, despite provision of windbreaks in each paddock.

Table 5. Effect of winter feed system on estimated dry matter and energy intakes and body weight change

	DMI[z] (kg cow^{-1} d^{-1})	TDN[y] (kg cow^{-1} d^{-1})	BWC[x] (kg)
2005-2006			
Drylot	11.6	7.2	23.4*a*
Bale Graze	12.7	7.8	10.3*ab*
Straw/Chaff	11.8	6.8	9.4*ab*
Swath Graze	10.3	6.3	-7.9*b*
SEM[w]	0.47	0.29	4.21
2006-2007			
Drylot	14.3	10.1a	32.9*a*
Bale Graze	13.9	9.8*a*	14.7*ab*
Straw/Chaff	13.6	7.5*b*	6.5*b*
Swath Graze	13.3	8.9*ab*	28.1*a*
SEM	0.83	0.45	5.18
2007-2008			
Drylot	14.2	9.5	7.1
Bale Graze	13.9	9.4	8.3
Straw/Chaff	14.6	8.9	5.1
Swath Graze	13.2	8.2	12.5
SEM	0.76	0.38	10.19

a-b Values in columns followed by different letters differ ($P < 0.05$)
[z]DMI = dry matter intake
[y]TDN = total digestible nutrients consumed
[x]BWC = body weight change; actual kg change during feeding period
[w]SEM = standard error of the mean

Initial rib fat was not different ($P>0.05$) for any year of the study (Table 4). However, differences ($P<0.05$) were seen in final rib fat between cows over the three years. In 2005-06 decreases ($P<0.05$) were observed for cows in the 3 extensive feeding systems (SG, ST/CH, BG) in rib (-0.9 mm) fat, while the DL cows gained rib fat (0.89 mm).

The greatest loss in body fat was seen in the ST/CH cows who lost an average of 1.5 mm of rib fat (Table 4). This may be attributed to the lower DMI and the low amount of TDN consumed by these cows (Table 5). Cows consuming straw-chaff piles with a supplement had variable weight gain over the three years of the trial, and the loss of body fat was reflected in the BWC.

Estimated dry matter intake (DMI), kg cow^{-1} d^{-1}, throughout each year of the study did not differ ($P>0.05$) between winter feeding systems (Table 5). Estimated DMI was slightly lower (2005-06) and similar (2006-07; 2007-08) to NRC (1996) requirements. To compare any differences in DMI between systems, the total digestible nutrients (TDN) consumed (kg cow^{-1} d^{-1}) in each system was determined. In year one of the study (2005-06) there were no observed differences in kg of TDN consumed between SG, ST/CH, BG and DL, however, there was a difference ($P<0.05$) in bodyweight change (BWC) between the SG and DL treatments. This difference may have been due to the environmental effect increasing the nutrient requirements of the SG system (McCartney et al. 2004). However, there was no difference in BWC between the three field feeding systems (SG, ST/CH, BG). Dry matter intake and TDN levels were sufficient to maintain bodyweight in ST/CH and BG, with the SG cows having the only negative (-0.1 kg d^{-1}) daily gain of all treatments. The DL treatment had the largest BWC, 23.4 and 32.9 kg in 2005-06 and 2006-07, respectively. Since animals were fed for maintenance and not gain, estimated DMI did not appear to be affected by treatment in any year.

Finally, estimated DMI for all cow groups was similar to NRC (1996) requirements. Based on a ration containing 60% TDN, dry pregnant beef cows with similar stage of gestation as the study cows should have a DMI of 11.28 to 11.90 kg. Extensive treatments had slightly higher DMI than NRC requirements which is similar to Baron et al. (2004) who reported DMI of swathed barley in excess of NRC (1996) requirements.

Cow reproductive data

Effect of winter feeding system on cow reproductive performance is reported in Tables 6 and 7. Winter feeding strategies were similar for the subsequent year's calf birth weight and calving pattern (Tables 6 and 7).

Table 6. Effect of winter feeding system on calf birth weight over 3 production cycles

Year	Swath Graze	Straw Chaff	Bale Graze	Drylot	SEM[z]
	----------kg----------				
2005-2006	45.86	49.95	47.29	46.10	2.09
2006-2007	42.69	42.40	44.02	43.45	1.06
2007-2008	42.94	40.49	40.25	41.94	1.26

Within row means having the same letter do not differ significantly ($p<0.05$).

[z]=SEM = standard error of the means

Table 7. Effect of feed system on reproductive performance over 3 production cycles

	Swath Graze	Straw Chaff	Bale Graze	Drylot
Calving pattern (% of total)				
2005-2006				
1-21 d	81.54	70.45	76.67	67.16
21-42 d	13.68	29.55	6.83	20.58
42-63 d	2.22	-	16.51	8.93
2006-2007				
1-21 d	73.33	79.21	73.33	70.32
21-42 d	24.44	9.21	22.22	25.08
42-63 d	2.22	11.59	4.44	4.60
2007-2008				
1-21 d	63.33	60.00	73.33	70.00
21-42 d	26.67	20.00	13.33	23.33
42-63 d	10.00	16.67	10.00	6.67

Within row means having the same letter do not differ significantly ($p<0.05$)

EFFECT OF WINTER FEEDING SYSTEM ON SOIL NUTRIENTS, SOIL DENSITY & CROP YIELD

Several parameters were measured to determine the effect of winter feeding system on soil and crop factors including soil nutrients, soil nutrient distribution, soil density and crop yield. In addition, a small plot manure application trial was conducted to determine the effect of raw versus composted manure application on the study site soil profile.

Soil Nutrients

Soil nutrient availability was measured in each winter feeding system paddock to determine the effects of extensive winter feeding system on plant available soil nitrogen (N), phosphorous (P), and potassium (K). Three cores were taken from each replicate plot (n=9) at the 0-15 cm and 15-30 cm depth increments. Cores were taken at the high, mid and low slopes throughout the plot. These cores were analyzed separately to determine if soil nutrients were affected by slope. Depth increments were bulked together for each plot.

Soil nutrient distribution was measured to determine the effect of winter feed system on soil nutrient flux and nutrient distribution of nitrogen and phosphorous. A 32 point grid (6.1 m X 7.6 m) was superimposed randomly on a feeding site in each field wintering system. Anion Plant Root Simulator probes (PRS) were inserted into the soil at each grid point for one week in May 2006, and this data was inputted into a computer programming model called Surfer 8.0™. The program then extrapolated outward from each data point to create a visual map of nutrient distribution throughout the treatment.

Soil nutrients were also measured to determine the effects of compost versus raw manure application on plant available soil nitrogen, phosphorous, and potassium. A small plot trial was conducted with three treatments and four replicate per treatment, with site dimensions for each replicate measuring 100 x 120 ft. Treatments included a check (no manure applied), 1X rate of manure (22.4 t ha^{-1}) and 1X equivalent rate of compost (6.72 t ha^{-1}). Three cores were taken from each replicate plot (n=12) at the 0-15 cm and 15-30 cm depth increments. Cores were taken at the high, mid and low slopes throughout the plot. These cores were analyzed separately to determine if soil nutrients were affected by slope. Depth increments were bulked together for each plot. Two anion Plant Root Simulator probes (PRS) were inserted into the soil in each replicate for one week in May 2006, and this data was used to determine soil nutrient flux.

Soil Density

Soil density was measured using a pentrometer technique. Measurements were taken from each of the grid points on the extensive feeding sites from the above mentioned grid pattern. This data allowed for an estimate of the effect of winter feed system on soil density. In addition four pentrometer measurements were taken from each of the manure application trial sites in order to estimate effect of manure application on soil density.

Crop Yield

Crop dry matter yield was measured using standing crop samples the following growing season to determine effects of winter feeding system on subsequent crop yield. Square meter quadrats (1.0 m^2) were taken in each winter feed system (n=15) and each manure application trial (n=5), in order to determine total biomass production. As well, one 32 point grid was set up in each winter feed treatment to determine pattern of biomass growth in relation to feeding site. At each data point square meter quadrats of the standing crop were taken.

Table 8. Effect of winter feed system on plant available nitrogen

Slope	Swath Graze	Straw/Chaff	Bale Graze
NO_3, kg ha^{-1}			
High Slope	41.8	42.0	38.3b
Mid Slope	29.6	58.7	27.9b
Low Slope	71.8	35.3	61.4a
P-value	>0.10	>0.10	<0.10
NH_4, kg ha^{-1}			
High Slope	8.3	6.8	7.4
Mid Slope	7.4	7.6	6.8
Low Slope	6.8	6.5	7.1
P-value	>0.10	>0.10	<0.10

a-b Values in columns followed by different letters differ (P<0.10)

Soil extractable nitrogen

Soil extractable nitrate nitrogen (NO_3) levels were affected significantly (P<0.10) in the bale graze treatment by landscape, with levels of 38.3 kg ha^{-1} at the high slope increasing to levels of 61.4 kg ha^{-1} at the low slope (Table 8). This could be attributed to the physical attributes of the feeding system. With increased concentration of feed per area in the bale graze system, the nutrient density per area is increased, thus amplifying the potential leaching of nutrients through the soil profile. The increased probability for leaching in a bale graze system should be noted as a potential environmental concern and these systems should be managed properly. Since NO_3 is a negatively charged ion it is more likely to leach through the soil profile (Brady and Weil 2002). Levels of NO_3 were not affected significantly (P<0.10) by landscape in the swath graze, however levels numerically increased from 41.8 kg ha^{-1} at the high slope to 71.8 kg ha^{-1} at the low slope, demonstrating the influence topography has on the soil nutrient profile (Table 8). In concurrence with the first two treatments, levels of soil extractable NO_3 straw/chaff graze treatments were affected numerically by landscape, however higher levels of NO_3 were not seen in the low slope, but instead in the mid slope position. Although landscape had an effect on soil extractable nitrogen, particularly in the bale graze treatment, treatment itself did not have a significant effect on soil extractable nitrogen levels (Figure 1).

Levels of ammonium nitrogen (NH_4) throughout all treatments were affected numerically, however not significantly (P>0.10). Landscape did not affect NH_4, most likely due to the fact that ammonium ions are positively charged and therefore they are subject to adherence to the negatively charged soil particles, thus decreasing the potential for leaching from the soil profile (Brady and Weil 2002).

Figure 1 represents the effect of winter feeding system on soil nitrogen distribution.

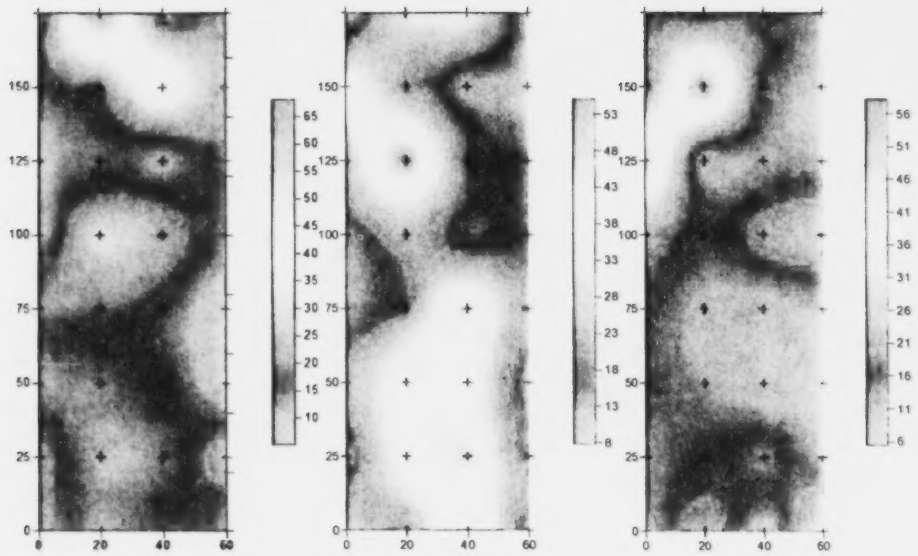

Figure 1. Effect of winter feeding system on soil N distribution (μg cm^{-2})

Nitrogen distribution within treatments was affected by the swath graze treatment, as shown in Figure 1, and is associated with feeding site. The swath graze treatment had greater distribution of feed, when compared to the bale graze treatment, thus increasing the nutrient distribution. The bale graze and straw/chaff treatments had high levels of nitrogen situated around the feeding site. These increased N levels can be visually seen in the top portion of Figure 1. The straw/chaff treatment had decreased nitrogen distribution, possibly due to the lack of available nitrogen in the feed prior to start of trial which would decrease the amount of available nitrogen to be captured by the soil. Also, a high amount of carbon associated with the straw may have tied up available nutrients rendering them unavailable at the time the soil samples were taken. A high C:N ratio will cause immobilization of nitrogen. The amount of immobilization that occurs is directly related to the amount of residue. Cereals that produce a large amount of dry matter subsequently have larger amounts of residue that will contribute to increase immobilization. Carbon to nitrogen ratios greater than 20 will result in immobilization of nitrogen. Straw on average contains a C:N ratio of 80, therefore it is most likely that some immobilization occurred in the straw/chaff treatment (Manitoba Agriculture Food and Rural Initiatives 2007)

Soil extractable nitrate nitrogen (NO_3-N) levels from the raw and compost manure application are represented in Figure 2. Nitrate levels were the lowest in the composted treatments, with levels reaching 48.87 kg ha^{-1} at the 0-15 cm depth and 42.12 kg ha^{-1} at the 15-30 cm depth. There was a significant difference ($p<0.10$) between the control and

the compost treatment at the 0-15 cm depth, with NO_3-N levels of 48.87 kg ha^{-1} in the compost treatment and of 66.15 kg ha^{-1} in control treatment. The higher levels NO_3-N in the control could be a result of a high N:C ratio of the compost which would tie up the available N resulting in a lower amount of soil extractable NO_3-N. This is also visible in the significant difference found between the raw and compost treatment. The compost treatment had soil extractable NO_3-N levels of 48.87 kg ha^{-1} while the raw manure treatment had levels of 62.6 kg ha^{-1}. These are similar results to Jungnitsch (2008), who found no significant increase in inorganic nitrogen levels from compost or raw manure application the following spring after application. The land where the study occurred had a history of manure application, which would explain the high levels of NO_3-N in the control treatment. There was no significant difference between treatments at the 15-30 cm depth, however a numerical difference was apparent. NO_3-N levels were numerically highest in the control treatment.

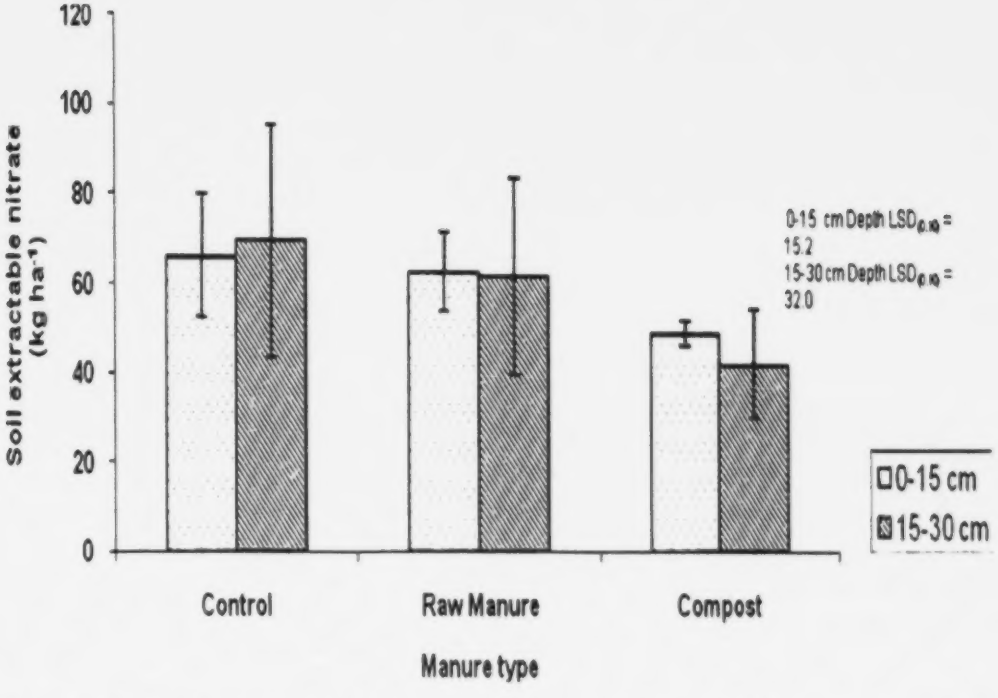

Figure 2. Effect of manure application treatment on soil extractable nitrate nitrogen levels

Phosphorous

Landscape effects were also seen in the straw/chaff treatment with increased P levels of 50 and 125 kg P ha-1, in the mid and low slope areas (Figure 3). Phosphorous (P) distribution patterns were seen to correlate with feeding site, and parallels could be drawn between manure distribution and crop biomass the following year (Figure 3). Soil P distribution differences were seen between treatments, with higher levels of P surrounding the feeding sites in each treatment. Straw/chaff grazing showed the greatest visual distribution of P with increased levels of P running horizontally through the feeding site.

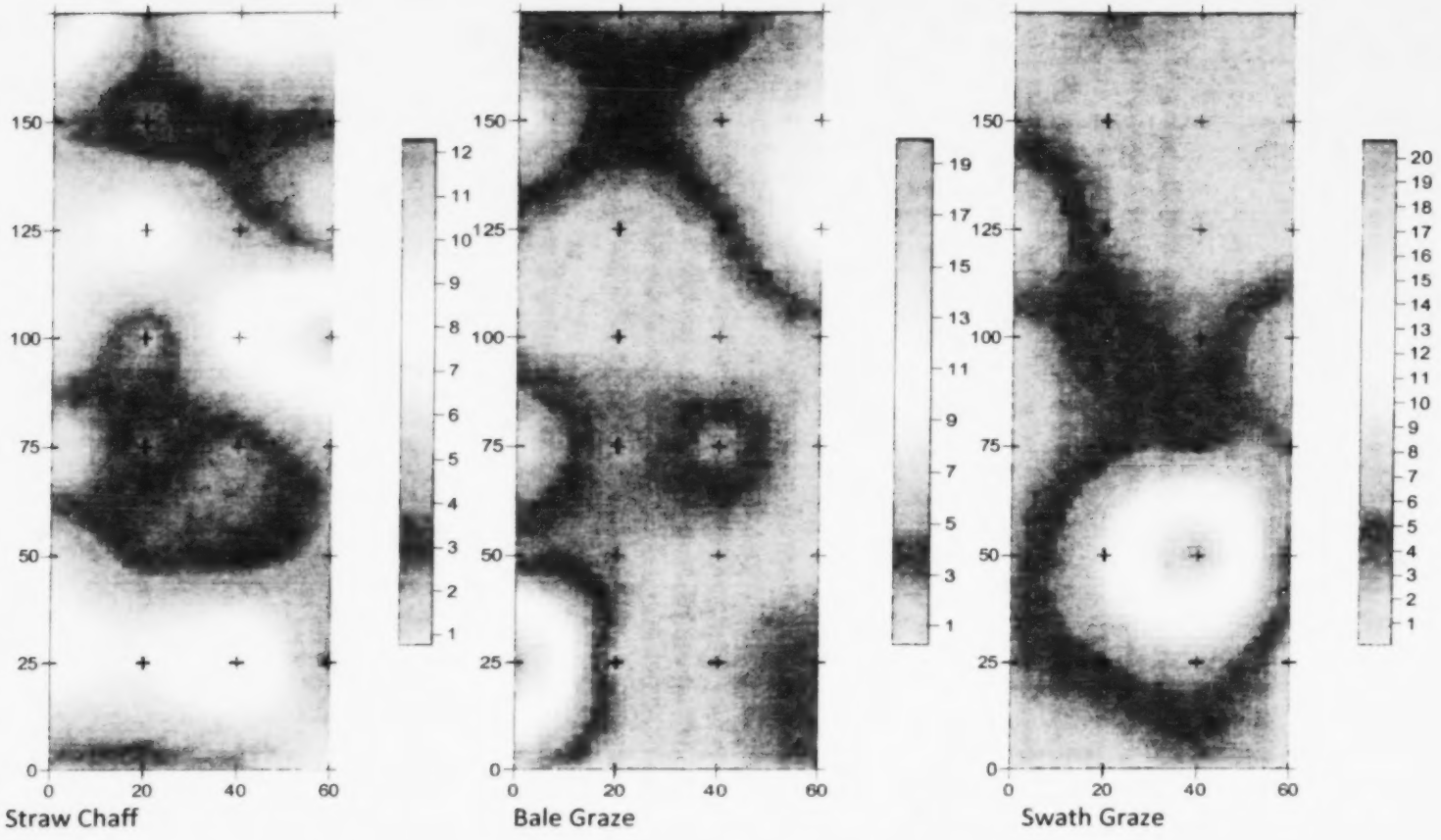

Figure 3. Effect of winter feeding system on pattern of soil P distribution

The lack of significant difference in amount of P could be due to history of manure application on the current annual cropped field. Soil nutrients were not limiting, as in a similar study by Jungnitsch et al. (2005) on which animals were wintered on a Russian wild ryegrass pasture. Jungnitsch et al. (2005) had higher animal stocking densities at 830 cow days ac^{-1}, whereas the current study had a lower stocking density of 114 cow days ac^{-1}, thus concentrating the effects observed in the Jungnitsch et al. (2005) study. It can be suggested then that differences in stocking density could have a significant impact on the amount of retained soil phosphorous.

Soil Density

Winter feeding systems affected soil density across sites, with the bale grazed system having the greatest effect and the straw/chaff grazed treatment having the least effect on soil density at the 5 cm soil depth (Figures 4 and 5). Soil density was decreased nearly 50% by the straw chaff group when compared to the bale graze group, indicating definite differences in soil tilth between treatments (Figure 4). These results may be explained by the increased concentration of feed per feeding site in the bale graze treatments which ultimately resulted in greater animal density per feeding site in this treatment. Stephenson and Veigel (1987) determined that soil bulk density of pastures with a loam soil texture used for winter feeding was affected as stocking density increased to 40 head per hectare. For this study stocking density was maintained at 3.75 animals per ha across all treatments, however stocking density at the bale feeding site could potentially increase to 136.6 head per hectare. Each bale was placed within a 0.11 ha site with 15 cows feeding on the 0.11 ha area, thus the site having a potential stocking density of 136.6 head per hectare. Stephenson and Veigel (1987) determined that damage associated with soil compaction due to winter grazing on pastures, showed a 92% recovery after 2 years of protection from grazing and trampling. This validates then the importance and length of time needed for full recovery of compacted soils.

The greater distribution of feed in the swath graze and straw/chaff treatments allowed for greater dispersal of animals and therefore decreased the amount of soil compaction that occurred in these winter feeding system areas. Although differences in compaction were seen between feeding systems, overall compaction was not an issue in management of the residue and crop production the following year. Heavy harrows were used to break up and spread remaining feed residue in the spring, and good germination was observed during the growing season.

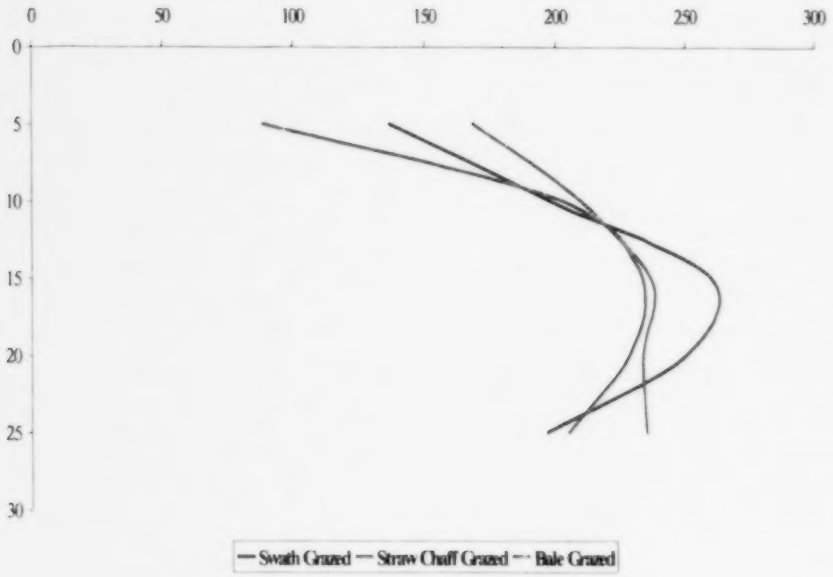

Figure 4. Effect of winter feeding system on soil density (Newtons cm $^{-2}$)

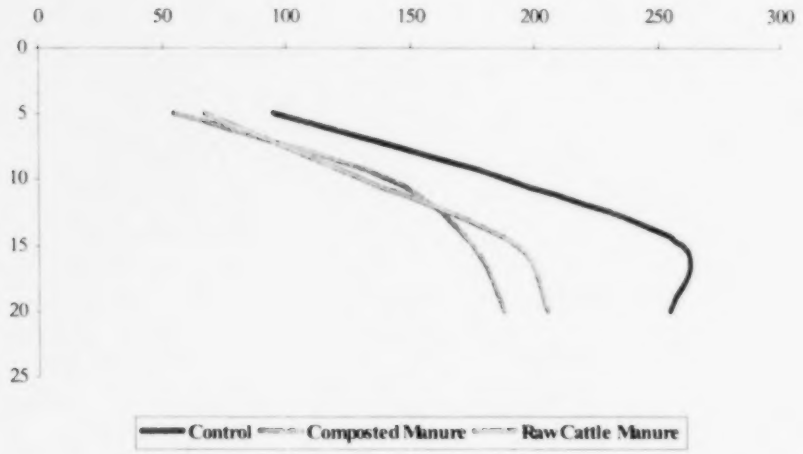

Figure 5. Effect of manure application treatment on soil density (Newtons cm $^{-2}$)

Crop yield

Crop biomass the following year differed between feed systems (Figure 6). Bale graze groups yielded on average 13% higher than the straw/chaff groups, however the straw/chaff group still yielded very well at 6299 kg ha^{-1} (Table 9). The difference could be attributed to the large carbon mass associated with the straw which may immobilize available nutrients due to a large carbon to nitrogen ratio. Carbon to nitrogen ratio is an excellent predictor of N availability in manure, which was shown by Qian and Schoenau (2001), who determined that N availability decreased dramatically when C:N ratio increased past 15:1. Manure application treatment did not have a significant effect on crop biomass (Figure 7), which could be attributed to a long history of manure application on the study site, therefore the soil was not nutrient limiting.

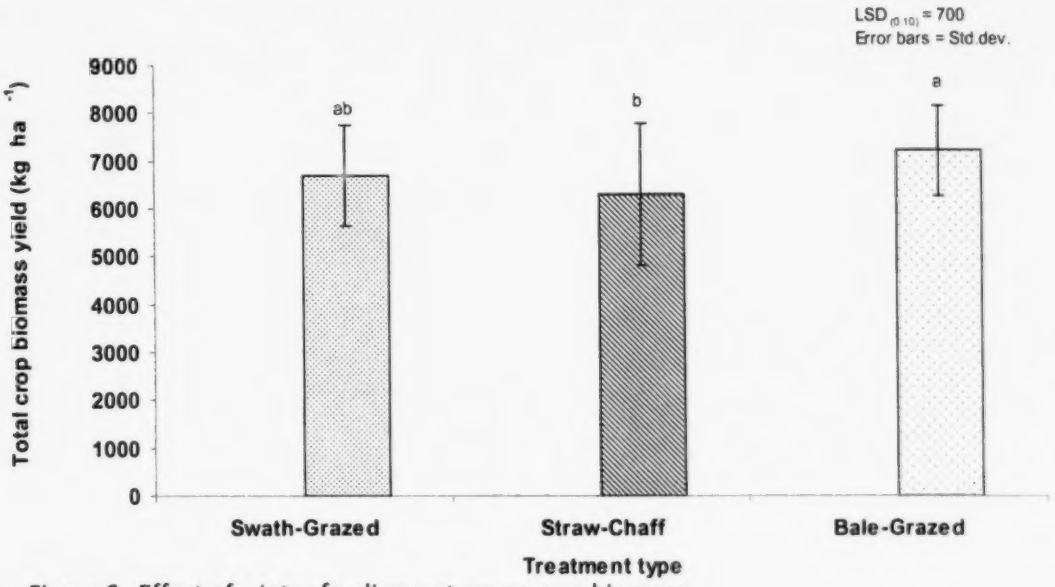

Figure 6. Effect of winter feeding system on crop biomass

Table 9. Effect of winter feed system on crop biomass (kg ha^{-1})

Swath Graze	6685*ab*
Straw/Chaff	6298*b*
Bale Graze	7210*a*
P-value	<0.10

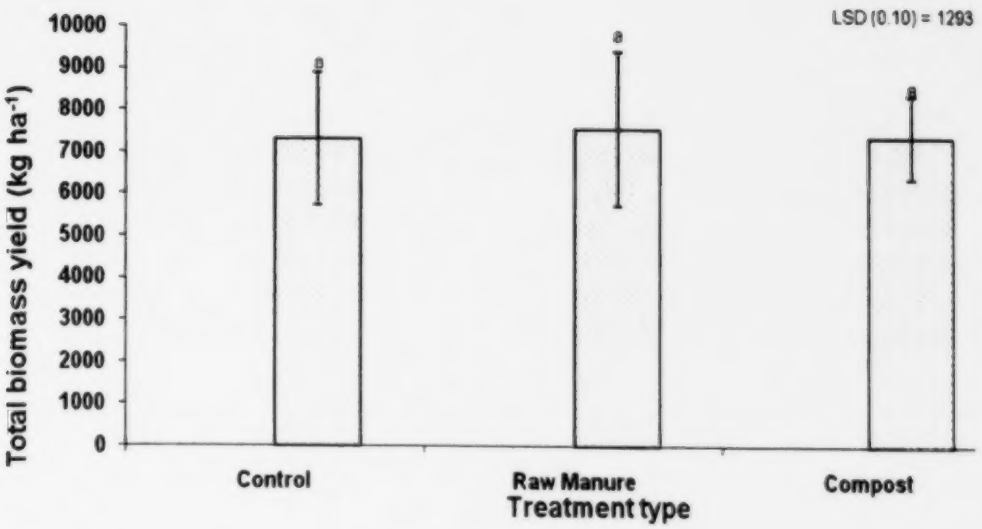

Figure 7. Effect of manure application treatment on crop biomass

ECONOMIC COMPARISON OF WINTERING SYSTEMS

Economic analysis of the winter feeding systems incorporated costs associated with crop production and costs associated with animal grazing. The analysis included costs related to feed production, labour, and equipment for each treatment. Costs of infrastructure such as capital setup expenses, and maintenance of shelters, temporary and permanent watering systems, temporary and permanent fencing were not included, as these were deemed outside the scope of this project and it was assumed that these would be included in all feeding systems.

Costs were calculated by system and are reported as cost per cow per day. The feed associated with the drylot was stored near the feed sites and costs included the direct daily cost of supplying the feed with no additional costs associated with hauling the feed to the feed site. All feed for the extensive winter feed systems was produced on the feeding sites therefore no costs were incurred for transportation of the feed.

Equipment costs were calculated using Saskatchewan Ministry of Agriculture's Farm Machinery Custom and Rental Rate Guide (Saskatchewan Ministry of Agriculture 2006 & 2007). Total variable costs included costs associated with repair, fuel, and lube/oil. Total fixed costs were added to total variable costs, which were then used to determine a cost per hour. All equipment costs were based on per hour of use determined by multiplying total cost per hour by the time spent using the equipment to determine total equipment cost. The time spent feeding was measured each year by timing the feeding process, and then determining equipment operation and feeding labour. Labour was calculated at \$15.00 hr^{-1}. Custom manure removal was estimated at

$0.03 cow^{-1} day^{-1} similar to study conducted at the same facility the previous year (Jungnitsch 2008). Costs are calculated for 2005-06 and 2006-07.

Crop production expenses

Crop production expenses included all costs associated with production of the crop and are listed in Table 10. This included land preparation pre-seeding, pre and post seed herbicide application, seed, seeding, swathing, baling, harvesting and transportation of grain, bale hauling, land rent, depreciation of the whole buncher, and were based on custom rates from the Farm Machinery Custom and Rental Rate Guide (Saskatchewan Ministry of Agriculture 2006 & 2007).

Table 10. Crop production costs for 2005-06 and 2006-07

	Swath Graze	Bale Graze	Straw/Chaff	Drylot
2005-2006		$ ha^{-1}		
Land Preparation	5.66	5.66	5.66	5.66
Pre-seed Herbicide	25.30	25.30	25.30	25.30
Seed	9.88	9.88	9.88	9.88
Seeding	22.81	22.81	22.81	22.81
Fertilizer	47.85	47.85	47.85	47.85
Post-seed Herbicide	50.43	50.43	50.43	50.43
Swathing/Cutting Hay	33.16	36.67	33.16	36.67
Land Rent	74.13	74.13	74.13	74.13
Combining	-	-	51.40	-
Hauling Grain	-	-	21.42	-
Baling	-	71.41	-	71.41
Bale Placement/Hauling	-	20.75	-	25.21
Grain Revenue	-	-	323.38	-
Depreciation (Whole Buncher)	-	-	7.41	-
Total	*269.24*	*364.91*	*26.09*	*373.74*
2006-2007				
Land Preparation	5.19	5.19	5.19	5.19
Pre-seed Herbicide	22.81	22.81	22.81	22.81
Seed	14.83	14.83	14.83	14.83
Seeding	27.60	27.60	27.60	27.60
Fertilizer	48.44	48.44	48.44	48.44
Post-seed Herbicide	46.28	46.28	46.28	46.28
Swathing/Cutting Hay	29.55	38.10	29.55	38.10
Land Rent	74.13	74.13	74.13	74.13
Combining	-	-	55.95	-
Hauling Grain	-	-	21.42	-
Baling	-	99.46	-	99.46
Bale Placement/Hauling	-	20.76	-	26.69
Grain Revenue	-	-	328.65	-
Depreciation (Whole Buncher	-	-	7.41	-
Total	*268.83*	*397.59*	*24.96*	*403.5?*

Crop production costs were identical across all treatments for the initial growth stage of the crop with differences in costs associated with the final harvesting stage of production. Costs were similar for each year of the study, with costs increasing slightly in the second year due to increases in seed, custom rates, and input prices. Total crop

production costs ($ ha^{-1}) for 2005-06 were 269.24, 364.91, 26.09, and 373.74 for SG, BG, ST/CH, and DL respectively. For 2006-07, total crop production costs ($ ha^{-1}) were 268.83, 397.59, 24.96, and 403.50 for SG, BG, ST/CH, and DL respectively.

The BG and DL treatments had the extra costs associated with baling, placement and hauling of the bales which increased the costs of production for these treatments. Expenses for placement of the bales was determined by timing the tractor used to place the bales and multiplying this by the custom tractor rate from Farm and Machinery Custom and Rental Rate Guide (Saskatchewan Ministry of Agriculture 2006 & 2007). The ST/CH treatments had the added cost of combining and hauling grain, however this was offset by the revenue generated by the grain harvested. Total crop production costs for this treatment were on average 13.58% lower compared to the other treatments, thus validating the economic benefits of using crop residue as a source of winter feed for cows (Table 1). Depreciation of the whole buncher for the ST/CH treatment was added each year for a total cost of $7.41/ha.

Grazing expenses

Grazing expenses included the cost of the feed, feed residue associated with each feeding system, supplementation required by the ST/CH treatment, labour, and equipment (Table 11). Labor includes total hours for moving fences, cows, windbreaks, and daily watering of cows. The cost of the feed was determined by the crop production costs per kg of feed produced multiplied by the kg of feed consumed. For both years of the study the BG and DL treatments had the greatest feed cost, due to the increased equipment usage required for crop production. Feed expenses ($ kg^{-1}) (Table 9) were the lowest for the ST/CH treatments due to the revenue associated with the harvested grain from this treatment.

Table 11. Grazing costs for wintering systems

	2005-2006			2006-2007		
	Provided	Cost		Provided	Cost	
	kg cow^{-1} day^{-1}	$ kg^{-1}	$ cow^{-1}	kg cow^{-1} day^{-1}	$ kg^{-1}	$ cow^{-1}
Swath Graze	10.30	0.04	0.36	13.33	0.03	0.40
Bale Graze	12.70	0.05	0.66	13.93	0.07	0.98
Straw/Chaff	7.19	0.02	0.14	9.46	0.02	0.27
Supplement	3.57	0.21	0.73	4.10	0.25	1.01
Drylot	11.64	0.04	0.62	13.87	0.07	0.97

Feed residue was measured in the spring and was used to calculate a value for the amount of feed left uneaten. Residue costs were highest in 2005-06 in the drylot feeding system at $0.37 cow d^{-1} with the BG treatment having the second highest residue amount with an associated cost of $0.30 cow^{-1} d^{-1} (Table 12). In the first year of

the study the straw/chaff treatment had the lowest cost associated with residue, $0.03 cow^{-1} d^{-1}. In 2006-07 the SG wintering system had the lowest associated residue cost of $0.03 cow^{-1} d^{-1}.

Total straw-chaff costs were dependent on the cost of supplementation in this study (Table 10). Supplement (range pellet) cost was valued at $0.30 per kg compared to rolled barley valued at $0.15 per kilogram. The total cost of the straw-chaff treatment could have been reduced with a more economical supplement and producers should be encouraged to source cheaper forms of supplementation.

Table 12. Economic summary of winter feeding systems

	Cost			
	Swath Graze	Bale Graze	Straw/Chaff	Drylot
2005-2006	----------$ cow^{-1} day^{-1}----------			
Feed	0.36	0.66	0.14	0.62
Residue	0.08	0.30	0.03	0.37
Supplementation	-	-	0.73	-
Labour	0.23	0.04	0.13	0.04
Equipment	0.25	0.08	0.29	0.13
Manure Cleaning	-	-	-	0.03
Total Cost	0.92	1.08	1.32	1.19
2006-2007				
Feed	0.42	1.01	0.18	1.06
Residue	0.03	0.28	0.09	0.15
Supplementation	-	-	1.01	-
Labour	0.18	0.08	0.09	0.04
Equipment	-	-	-	0.14
Manure Cleaning	-	-	-	0.03
Total Cost	0.63	1.38	1.38	1.42

In this study, winter grazing cows on bale grazing or straw-chaff systems was more cost effective (5% less) than feeding in a pen. Finally, winter feeding cows in a swath gazing system greatly reduced daily cost per cow by 23 and 56% over the two years, compared to feeding in drylot pens.

IMPLICATIONS

This research has shown the benefits from managing dry pregnant beef cows in winter grazing systems. The feeding value of forage barley (cv Ranger) at the time of swathing varied only slightly from year to year and would be adequate to provide the nutritional requirements of pregnant beef cows. Utilization rates indicated efficient grazing, and daily cow estimated intake rates were similar to NRC-predicted minimum requirements for mid-pregnancy stage cows. Cows might be expected to consume a variety of swath components during the grazing period ranging from recently swathed whole-plant barley containing grain to that of straw and residue material, which had considerably lower feeding values than the standing crop before swathing.

Snow conditions (Lawrence and Heinrichs, 1974) and low temperature (Adams et al. 1986) may impede grazing or reduce the drive of cows to graze. In the current study there was freezing rain and abnormally high snowfall in October and November of 2006, followed by freezing that resulted in some of the bottom material in the swaths and piles becoming frozen to the ground. In addition, snowfall in December of 2006 and January of 2007 was above average. These factors likely made it difficult for the cows to forage as efficiently as they did in other years. Variation in feed quality over the winter and occasional severe weather would likely result in periods of energy deficiency.

Swath-grazed cows had more weight change over the winter feeding period in 2005-06 than cows fed either in bale grazing, straw-chaff or in drylot. However, this had no effect on the reproductive performance of the swath grazed cows and all cows were in similar body condition (2.5-2.7). Considerable labour and cost savings were obtained from swath grazing (56% less), straw-chaff (5% less) and bale grazing feeding (6% less) compared to managing cows in drylot pens during the winter. These results indicate extended grazing systems for wintering pregnant cows can result in reduced costs without sacrificing cow reproductive performance.

Finally, benefits derived from manure nutrients in field feeding systems provide much needed plant nutrients for the next cropping season. Thus, the adoption of swath grazing, bale grazing and utilizing crop residue feeding strategies would result in large improvements in production efficiency and global competitiveness for cow-calf managers in the central and northern Aspen Parkland of Western Canada.

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PERSONNEL INVOLVED

Breeanna Kelln - MSc Graduate Student, Department of Animal & Poultry Science, University of Saskatchewan.

Dr Bart Lardner - Project Supervisor, Western Beef Development Centre; Department of Animal & Poultry Science

Dr Jeff Schoenau, Department of Soil Science, University of Saskatchewan

Kathy Lang, Beef Economist, Western Beef Development Centre

PROJECT EXTENSION ACTIVITIES & PUBLICATIONS:

FIELD DAYS:

Project results presented to producers at WBDC Summer Field Days:

- June 27, 2006
- June 26, 2007

PUBLICATIONS:

Published Conference Proceedings:
Kelln, BM, Lardner, HA, Schoenau JJ, King, T and Lang K. 2007. Effects of winter feeding systems on cow performance, soil nutrients and crop biomass. Journal of Animal Science. 85 (Suppl. 1) :760 (Abstr.)

HA Lardner, P Jungnitsch, JJ Schoenau, B Kelln and T King. 2007. Nutrient Management of Beef Cow Winter Feeding Systems. Proceedings of the 2007 Manure Management Conference – Adapting & Innovating for Sustainability. Winnipeg MB.

B Kelln and HA Lardner. 2007. Effects of Winter Feeding Systems on Soil Compaction, Soil Nutrients and Cost of Production. Proceedings of the Canadian Section of American Oil Chemists' Society-Canadian Society for Nutritional Sciences-Canadian Society of Animal Science 2007 Joint Meeting. Winnipeg MB.

T King, JJ Schoenau, HA Lardner and B Kelln. 2007. Effect of Winter Feeding Systems on Soil Nutrients. Proceedings of the Soils & Crops Workshop. University of Saskatchewan. Saskatoon SK.

Articles Published:

- Canadian Cattlemen Magazine Fall 2007 *"Winter Feeding Systems for Beef Cattle"*
- Livestock and Forage Gazette November 2007 *"Winter Feeding Systems for Beef Cattle"*
- Hay and Forage Grower, February 2007 *"Bale Grazing - Winter Feeding Method Simplifies Herd Management"*
- Canadian Cattlemen Magazine Fall 2006 *"Wintering Cows on Stubble Looks Like an Option" and "Winter Feeding Improves Forage Stands"*

WBDC Fact Sheets Published:

- Effect of Winter Feeding Systems on Beef Cow Performance and Crop Yield
- Effect of Winter Feeding Systems on Soil Nutrients, Soil Distribution and Soil Compaction

CONFERENCES:

Research results were presented at the following meetings:

- 2007 Saskatchewan Beef Symposium, Saskatoon, SK. February 2007 (paper presentation)
- Canadian Society of Animal Science Annual Conference, Winnipeg, MB. June 2007 (poster presentation)
- American Society of Animal Science Annual Conference, San Antonio, TX. July 2007 (paper presentation)

Statement of Expenditures

A final statement for the project is included. All expenditures were in compliance with BDF guidelines. This project is all but finalized with the exception of a thesis defence. Ms. Kelln is near completion of her M.Sc. thesis. She is due to defend in Spring 2009. A copy will be forwarded to Saskatchewan Beef Development Fund, Agriculture Research Branch, Ministry of Agriculture at that time.

PROJECT EXPENDITURES:

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